and almond; and of tropical drug- or food-yielding species *Theobroma cacao*, *Croton Eluteria* and *Tiglium*, *Paullinia sorbilis*, and *Mallotus philippinensis*. As far as possible the plates have been drawn from living specimens. They are drawn and lithographed by Mr. Blair, a young and rising botanical artist, and are well executed, with abundant structural detail and colouring not overdone, though in some cases (e. g. *Mentha viridis* and *Digitalis purpurea*) the pictorial effect is marred by superabundance of shading. The letterpress, both botanical and pharmacological, is full and accurate; and altogether the book may be safely recommended as likely to be a complete and trustworthy handbook for medical men, chemists, and all who are interested in the subject.

PROCEEDINGS OF LEARNED SOCIETIES.

ROYAL SOCIETY.

November 25, 1875.—Dr. J. Dalton Hooker, C.B., President, in the Chair.

"On the Structure and Relations of the Alcyonarian *Heliopora cærulea*, with some Account of the Anatomy of a Species of *Sarcophyton*; Notes on the Structure of Species of the Genera *Millepora*, *Pocillopora*, and *Stylaster*; and Remarks on the Affinities of certain Palæozoic Corals." By H. N. Moseley, M.A. (Oxon.), Naturalist to the 'Challenger' Expedition.

Introduction.—The author having undertaken the examination of the Deep-sea Corals dredged during the voyage of H.M.S. 'Challenger,' was led to the study of the structure of corals generally, and especially to the examination of the Milleporidæ, which seemed of peculiar interest, since they had been determined by Professor Agassiz to be Hydroids, and had been regarded by him as living representatives of the Palæozoic Rugosa. *Millepora alcicornis* was obtained and examined at Bermuda, and another species of *Millepora* at Zamboangan, Mindanao, Philippine Islands. The examination of these Millepores was found to be beset with great difficulties, and the present notes on their structure are to be regarded as only preliminary. Further investigations will be made with specimens which it is hoped will be obtained at the Sandwich Islands. At Zamboangan, *Heliopora cærulea* was obtained, and found at once to be an Alcyonarian. Its structure is described in full in the paper. Another Alcyonarian of the genus *Sarcophyton* (Lesson) was examined for the purpose of comparison. It proved to present special features of interest, and a general description of its anatomy also is therefore given. Notes are further appended on the anatomy of a species of *Pocillopora* obtained at Zamboangan,

and that of a Stylasteracean dredged off the Meangis Islands in 500 fathoms.

Literature of the Subject.—Few original works relating to the subjects treated of in this paper were available for reference on board the 'Challenger.' A review of what has been able to be gathered of the recent literature relating to the Tabulate and Rugose Corals and the Alcyonarians is given, and also a history of the various systematic arrangements to which the Tabulata and Rugosa have been subjected.

Professor Agassiz published his opinion as to the hydroid affinities of the Milleporidæ in 1859 ("Les Animaux des Millépores sont des Acalèphes et non des Polypes," Bibl. Univ. de Genève, Arch. des Sci., Mai 1859), and figured the animals of the *Millepora alcicornis* in his 'Contributions to the Natural History of the United States,' vol. iii. plate 15. Pourtales observed the animals in company with Agassiz. He says that one which he saw was "shorter than they are represented to be in the figure, and had five tentacular masses rather than tentacles." M.-Edwards considered Professor Agassiz's evidence as to the hydroid nature of *Millepora* insufficient, as does also Professor Allman.

Professors Claus, Pourtales, Verrill, and many other authors accept Agassiz's conclusion with regard to the Milleporidæ, but do not accept his views with regard to the Rugosa.

Professor Verrill (Silliman's American Journal, 1872, vol. iii. pp. 187, 194) found that *Pocillopora*, a genus with extremely well-marked tabulæ, was a true Hexactinian, and showed that the presence of tabulæ, the character relied on by Professor Agassiz, was of little importance. Pourtales and L. Ludwig have come to the conclusion that the tetrameral arrangement in the Rugosa is merely apparent, and that the original arrangement in the young coral was hexameral. Professor Martin Duncan arrived at similar conclusions from the examination of *Guynia annulata*. Kunth, however, still adheres to the tetrameral primary division. Lindström, the first discoverer of the opercular apparatus of certain Rugosa, compares these structures with skeletal structures of *Primnoa*. The latest paper on the classification of Corals is by M. Dollfus (Comptes Rendus de l'Acad. des Sciences, t. lxxx. no. 10, 8 Mars 1875, pp. 681–683). M. Dollfus connects together the genera *Heliolites* and *Propora* with *Heliopora* and *Seriatopora* by means of *Pocillopora*, considering all these to be Hydroids. *Favosites*, with many other genera of Palæozoic Corals, he considers to be a Bryozoon.

Methods employed.—The corals examined were hardened in alcohol or chromic acid, decalcified, and cut into fine vertical and horizontal sections. Sections of the hard parts were rubbed down in the usual manner. Portions of *Heliopora cærulea* were also examined in the fresh state.

On the Structure of Heliopora cærulea.—*Heliopora cærulea* was found growing in abundance on reefs near Zamboangan at low tide. The polyps were never seen expanded, though pieces of the

coral were carefully transferred to a glass vessel without being removed from the water. The living coral is perforated in all directions by a parasitic Annelid (*Leucodora*). The corallum of *Heliopora* is remarkable for the tubular character of its cœnenchym, which consists of a series of tubes arranged side by side at right angles to the surface of the coral, open above but closed below by successive transverse partitions or "tabulæ." The calicles are tubes essentially similar to the tubes of the cœnenchym, but larger. They are said by M.-Edwards to have twelve septa appearing as plications of the wall of their cavities. The number is, however, very variable. The tabulæ of the calicle are exactly similar in structure to those of the cœnenchym. The hard tissue is composed of doubly refracting calcareous matter, which has a half-crystalline, half-fibrous structure. It is disposed in a series of systems vertically to the surface of the corallum, the axes of which systems lie in the interspaces between the cœnenchymal tubes. In each system the fibres of hard tissue are disposed radially around the central vertical axes, and at the same time with an upward inclination at an equal angle all around.

The colony of *Heliopora* is developed entirely by budding. In a growing point of the corallum the cœnenchymal tubes are widely open and polygonal in outline. New calicles are formed by the junction of a number of tubes around a central tube or tubes arrested in growth which form a base. The outer walls only of the surrounding tubes continue to grow and form the lateral wall of the calicle. The newly formed calicle thus has tubular prolongations at its base; and the so-called septa are, in the main, due to the circumstance that the wall is composed of a series of fused curved outer walls of tubes. The calcareous matter is deposited in a finely fibrous calciferous tissue, connected apparently with the formation of which is a layer of connective tissue which everywhere covers the hard parts.

There is no trace of the corallum of *Heliopora* being composed of fused spicules as in the case of *Corallium* and *Tubipora**.

The deep blue colouring of the corallum of *Heliopora* is due to an amorphous colouring-matter insoluble in strong hydrochloric acid, but soluble in acidified alcohol. It forms an intensely blue solution of a sulphate of copper colour, which transmits the blue and part of the green only of the spectrum.

In the soft tissues of *Heliopora* an ectoderm, entoderm, and mesoderm are to be distinguished. The ectoderm is composed of club-shaped cells; it has the usual disposition. Small oval nematocysts are present in it and in the upper part of the mesodermic layer beneath. The mesoderm consists of three histological elements,

* The fact that the corallum is so formed in *Tubipora* seems to have been hitherto unknown (Claus, 'Grundzüge der Zoologie,' 3e Aufl. p. 204). It is plainly shown at the mouth of any growing tube in spirit specimens. Professor Wyville Thomson drew my attention to the fact, an account of which he thinks has been published by Professor Perceval Wright in the 'Annals and Magazine of Natural History.'

homogeneous connective tissue, layers of connective-tissue cells, and finely fibrous calciferous tissue. Prolongations of the two former form sacs lining the cœnenchymal tubes and calicles. The sacs are further lined by the entoderm, which consists of spherical cells containing yellow pigment, as in other Alcyonarians. Only a surface-layer in *Heliopora* is living. Hardly any soft tissue is to be found in the tubes beneath the last-formed tabula. The sacs lining the tubes do not communicate anywhere directly with the exterior, but are connected with one another above, and with the calicular cavities, by wide transverse canals. The superficial tissues are permeated by smaller canals. The polyps of *Heliopora* have eight mesenteries and eight lobed tentacles. In the contracted state of the polyp the tentacles are completely introverted, and rest in the intermesenterial spaces. The stomach is like that of any other Alcyonarian. Retractor muscles are present, which are disposed with regard to the mesenterial plates as in Pennatulids, showing a "Dorsalfach" and "Ventralfach." No definite protractor muscles were observed to be present. No regular arrangement of the eight mesenteries with regard to the twelve so-called septa could be found. Eight mesenterial filaments are present, two of which appear to be longer than the others. In three individuals only of the single colony examined were ova found—in one four ova, in the others only one. The ova are attached to the mesenteries. The four ova were attached to four separate mesenteries. No male elements were found. The colonies are probably unisexual. The arrangement of the polyps in the colony is somewhat irregular; but the "Dorsalfach" seems always to be uppermost in the vertical plates of which the coral consists, the polyps being thus placed back to back.

On the Structure of Sarcophyton, sp.—An Alcyonarian was obtained at the Admiralty Islands which agrees in every respect with Lesson's genus *Sarcophyton* (M.-Edwards, Hist. Nat. des Corall. t. i. p. 22). A genus called *Sarcophyton* is, however, cited by Claus as having been formed by Sars. The Alcyonarian is mushroom-shaped. Two kinds of individuals, zooids and polyps, compose the colony; the stem is composed of large tubes ("sinus"), the prolongations of polyp-cavities. The polyps offer no marked peculiarities; their retractor and protractor muscles are arranged as in Pennatulids with regard to the mesenteries. They have two mesenterial filaments longer than the rest. The zooids have eight short mesenteries, four of which, the "dorsal" and "ventral," are deeper than the rest. They have two mesenterial filaments, the dorsal only. They have no tubercles and no generative organs. They have a simple globular stomach, communicating by a short tube with the exterior, and lined with long cilia. A sarcosome of transparent homogeneous connective-tissue, containing small ramified nucleate corpuscles, connects the polyp- and zooid-cavities; these cavities are connected by vertical and horizontal systems of canals. The vertical canals are continuous with the bottoms of the zooid-cavities; they form networks of

canals in the sarcosome. The sarcosome contains elongate tuberculate spicules of the usual form, which are largest and most thickly set in the stem of the *Sarcophyton*. Smaller spicules are present in the tentacles of the polyps. The spicules show a special sheath of transparent tissue, in which structure was not seen. The "Dorsalfächer" of the polyps and zooids have a general direction towards the central axis of the stem and centre of the pileus; but both polyps and zooids are often more or less twisted on their axes.

On the Structure of Millepora.—The examination of *Millepora* is beset with serious difficulties; the present notes are merely preliminary. The calcareous cœnenchymal tissue of *Millepora* differs extremely from that of *Heliopora* in being reticulate, not tubular: in histological structure it is similar to *Heliopora*. The coral has only a thin superficial layer of soft living tissue, composed of a network of canals filled with cells resembling those of the canals of Alcyonarians, and covered externally with nematocysts. Two kinds of nematocysts, small and large, are present: the small ones are confined to the tentacles. Two kinds of polyps are present, large and small. Tentacles are present in both kinds; they appear to be four in number and compound. They are simply retracted by means of muscular fibres, which are arranged round the base of the cylindrical stomach radially, but, as far as has yet been seen, without any disposition in definite groups. No mesenteries have been seen.

On the Structure of Pocillopora (P. acuta).—The corallum is very dense and composed of definite prisms of calcareous matter, which show a transverse banding, somewhat like that of striped muscular fibres. The polyps have twelve tentacles, six large and six small, and twelve mesenteries with long mesenterial filaments coiled up. A very thin layer of living tissue covers the corallum; it is devoid of canals.

On the Structure of Stylaster.—A *Stylaster* dredged in 500 fathoms was found to have the tentacles disposed *between* the calcareous septa, as was shown to be the case in *Allopora oculina* by Sars (Forh. Selsk. Chr. 1872, p. 115). The septa are twenty-two in number, and the tentacles also twenty-two. The stomach has a conical projecting mouth or proboscis, as seen by Sars in *Allopora oculina*. It has apparently no inferior outlet. There are no well-defined mesenteries, and no mesenterial filaments. A very open network of soft tissue surrounds the stomach and tube leading to it from the circle of the tentacles. Suspended in this reticulate tissue are the testes, large sacs filled with spermatic cells disposed sometimes in one, sometimes in two vertical rows; they occupy the interior of the ampullæ. These corals are diœcious. *Cryptohelia* resembles *Stylaster* most closely in structure, and is also diœcious.

Vegetable Parasites.—The corallum of both *Millepora* and *Pocillopora* is permeated by fine ramified canals, formed by parasitic vegetable organisms of the same nature as those described by Dr.

Carpenter and Professor Kölliker as occurring in the shells of mollusks &c. The organisms were found in abundant fructification; they are green, but otherwise appear to be fungi, as are the parasites of shells &c. Similar parasites are to be found in various coralla from widely distant parts of the world.

Conclusions.

Heliopora is most undoubtedly an Alcyonarian. The number of its mesenteries, and the distribution with regard to them of the retractor muscles, the form and number of its tentacles, are decisive evidence in the matter; and this evidence is borne out by almost every item of histological structure. In the peculiar manner in which the retraction of the tentacles takes place, viz. by introversion, *Heliopora* seems to differ from all other Alcyonarians except *Corallium**. From both *Corallium* and *Tubipora*, *Heliopora* differs in that the hard tissue of its corallum shows no signs of being composed of fused spicules, but in its histological structure most closely resembles Zoantharian Corals. With the Milleporidæ and with the Pocilloporidæ and Seriatoporidæ *Heliopora* is allied solely on account of its possession of tabulæ. Now that an Alcyonarian is added to the list of various Anthozoa possessing these peculiar structures, their presence becomes of less classificatory importance even than Professor Verrill proved it to be. There can hardly be a doubt that *Seriatopora* will prove to be, like *Pocillopora*, a Zoantharian; and *Millepora* is certainly very different in structure from *Heliopora*. *Heliopora* thus stands quite alone amongst modern forms; and in the peculiar structure of its cellular cœnenchym it is so remarkable that it is unlikely that on examination of the soft parts of other corals, at present known from their coralla only, any near relatives of it will be discovered. Amongst extinct forms, however, *Heliopora* has several close allies, and the genus itself existed in the Cretaceous period. The genus *Polytremacis* differs apparently only in the more perfect development of the so-called septa, which reach to the centres of the tabulæ. The genus occurs in the Chalk, Greensand, and in Eocene formations. *Heliopora* has, further, a very closely allied palæozoic representative in *Heliolites*, in which the cœnenchymal tubes are provided with very closely placed tabulæ.

The three genera *Heliopora*, *Polytremacis*, and *Heliolites* differ from one another in so slight a degree that they are placed under the one genus *Heliopora* by Quenstedt. To include these three genera, a new family of Alcyonarians must be formed, for which the term Helioporidæ appears most suitable, which family may from the recent species be thus characterized:—

* I have found no information on this point in any of the text-books; but in Schmarda's 'Zoologie' there is a figure of *Corallium*, copied from Lacaze-Duthiers's 'Hist. Nat. du Corail,' in which the tentacles are drawn introverted as they are in *Heliopora*.

Family Helioporidæ.

A compact corallum present, composed of a fibro-crystalline calcareous tissue as in Madreporaria. Corallum consisting of an abundant tubular cœnenchym, and with calicles having an irregular number of lateral ridges resembling septa. Calicles and cœnenchymal tubes closed below by a succession of transverse partitions. Polyps completely retractile, with tentacles when in retraction introverted. Mouths of the sacs lining the cœnenchymal tubes closed with a layer of soft tissue, but communicating with one another and with the calicular cavities by a system of transverse canals.

The structure of the cœnenchym of the Helioporidæ is entirely unique amongst Anthozoa; no other form has a cœnenchym composed thus of a series of long tubes packed side by side, and lying parallel to the calicular tubes and at right angles to the surface. It is to be remarked that the tubes are like the calicles in being open above, that they have walls composed in exactly the same manner as those of the calicles, and that they are closed below at intervals in the same way by exactly similar tabulæ. Further, the soft tissues lining the cavities of the cœnenchymal tubes are identical in structure with those lining the calicular cavities, and the same transverse system of canals connects the summits of the tubes with one another and with the summits of the calicular cavities.

It seems by no means improbable that the cœnenchym here is composed of the tubes of absorbed polyps or zooids which have lost the rudimentary organs, which they still possess in such a form as *Sarcophyton*, and have become mere tubular cavities, whose openings to the exterior even have been obliterated; it seems impossible otherwise to account for the presence of the successions of tabulæ in the cœnenchymal tubes. The foregoing considerations are suggested by the circumstance that a series of fossil corals, grouped by M.-Edwards under the Tabulata, appear most probably to have been Alcyonarians as well as *Heliopora*.

The genus *Chætetes* was considered by Keyserling to have belonged to the Alcyonarians, because of the absence of septa in it, and the mode in which its polyps are grouped; but Milne-Edwards retains it amongst the Zoantharians, because of its close resemblance to the Favositidæ, in which the presence of septa is regarded as conclusive in deciding against Alcyonarian affinity. The presence of calcareous septa, however, must now be considered a character of less importance than it formerly was. As is seen in the case of *Heliopora* pseudo-septa may exist, which do not necessarily correspond in any way, in disposition or number, with the membranous mesenteries. In *Stylaster* and *Cryptohelia* the calcareous septa are obviously formed as infoldings of the margin of the calicles. Here the septa are between, instead of opposite to the tentacles; and membranous mesenteries appear to be

absent, or at all events rudimentary only. In the Favositidæ the septa seem to have been no more perfect than they are in *Heliopora*, and to have been most variable in number, but often twelve, as also in *Heliopora*. M.-Edwards describes from 10 to 12 septa in *Favosites gothlandica*. In *Michelinia favosa* 30 to 40 subequal septal striæ are to be made out at the upper margin of the wall of the calicle. I cannot refer to specimens; but it seems not unlikely that the septa in the Favositidæ were pseudo-septa as in *Heliopora*, and that these coralla were formed by Alcyonarians, the perforations in the walls having transmitted transverse canals like those of *Heliopora* and *Sarcophyton*, and the coralla being free of tabular cœnenchym, because none of the polyps were aborted as in *Heliopora*. Some Favositidæ seem to have formed a compound colony, consisting of polyps and zooids, as *Favosites Forbesii*, where a few large cells are seen set amongst numerous surrounding small ones. *Heliolites* seems to a certain extent to form a transition stage between a condition such as that in *Favosites Forbesii* and the condition in *Heliopora*; for in *Heliolites*, the more ancient form, the cœnenchymal tubes are regularly hexagonal, and apparently much more nearly equal in breadth to the calicles than in *Heliopora*. In the growing points of *Heliopora* the hard parts are made up of a series of open, often hexagonal tubes, and resemble *Favosites* in their surface aspect. In *Heliopora* the transverse canals pass over notches in the summits of the walls of the cœnenchymal tubes and calicles, in order to place these cavities in communication with one another. In *Favosites* the calcareous tissue surrounded the transverse canals, and the perforations in the walls of the calicles were thus produced.

If *Favosites* was an Alcyonarian, *Chætetes* was of course also of that group. The genus *Alveolites* amongst the Favositidæ is peculiar for the possession of three tooth-like prominences as the only representatives of septa. One tooth, well developed, is situate inside the calicle ; on that side of each calicle which lies externally in the colony, and opposed to this on the tip of the calicle next the interior of the colony, are a pair of rudimentary teeth. This arrangement reminds us at once of the distinction of dorsal and ventral mesenterial interspaces in Alcyonarians, and the direction of all the "Dorsalfächer" in *Sarcophyton* and *Heliopora* towards the central axis of the colony. In *Alveolites* the two teeth seem to correspond to the "Dorsalfach," and the single one to the "Ventralfach," the two teeth having occupied the space devoid of retractor muscles. Kölliker describes a series of teeth as existing at the margin of the calicle in *Renilla*, which follow a constant law in their relation to the septa. When only one tooth is present it is opposite the "Dorsalfach;" when three, one is opposite the "Dorsalfach," and the two others opposite the lateral "Ventralfach." In *Alveolites* the one tooth is ventral instead of dorsal. In *Syringopora* the septa seem to be very much of the same nature as in *Heliopora*; and in *Heliopora*, as already described, the tabulæ are not merely transverse floors, but the bottoms of

cups of hard tissue fitted inside the older tubes and calicles. In *Syringopora* this condition of the tabulæ is much more marked, and the corallum appears as if formed of a series of calicles fitted one within another.

A difficulty appears to arise from the peculiar mode of the development of the calicles by budding in *Heliopora*, the foldings of the walls of the calicles being due, to a considerable extent at least, to the formation of these walls from a circle of cœnenchymal tubes. The septa are, however, not entirely formed in this way. It would of course be of great interest to see whether the primitive calicle, in the developing *Heliopora* colony, forms calcareous septa.

Heliopora having so commonly twelve septa, and in conjunction with these eight mesenteries, it was at first thought that here some key would be found to the elucidation of the question of the relations of the tetrameral corals to the Hexactinians; but no definite arrangement of the eight mesenteries to the twelve septa could be discovered. Ludwig and Pourtales have concluded that the tetrameral condition in the Rugosa is the result of a modification of an originally hexameral arrangement—that the Rugosa are, in fact, modifications of the Hexactinian type. Kunth, however, using similar methods, has come to an opposite conclusion. Now that it is known that an Alcyonarian exists which constructs a solid calcareous corallum, in histological structure scarcely, if at all, to be distinguished from that of many Madreporaria, and that this Alcyonarian also possesses marked calcareous septa, which septa show, notwithstanding the octameral arrangement of the mesenteries, a hexameral disposition in being often twelve in number, it seems that the question of the affinities of the Rugosa may fairly be reopened. The presence of well-marked calcareous septa in *Cryptohelia* and other Stylasteridæ (which septa are equal to the tentacles in number, but nevertheless to be regarded, like those of *Heliopora*, as pseudo-septa) is significant. The marked tetrameral arrangement of the septa in Rugosa, and the presence in many forms of tabulæ, are certainly characters not opposed to the alliance of these corals with the Alcyonarians; and the fact that paired series of opercula occur in certain Rugosa, which are compared by Lindström, their discoverer, to the skeletal structures of certain *Primnoæ*, seems to be evidence in favour of such an alliance of the very strongest kind. In no Madreporaria do paired hard structures, at all resembling those of *Primnoæ* or of *Goniophyllum pyramidale*, occur. The opercular structures in the coralla of *Cryptohelia* and *Lepidopora* can scarcely be regarded as comparable with the opercula of Rugosa. The structures are merely folds of the lip of the calicle, and are continuous with it and immovable, not movable separate articulate structures. Many Rugosa show an arrangement which may well be compared to the distinction of dorsal and ventral regions in Alcyonaria. The most important distinctive character of the Rugosa appears to be the

occurrence in them, alone of all Anthozoa, of intracalicinal gemmation*.

With regard to *Sarcophyton*, the fact that compound colonies composed of multitudes of zooids, combined with a lesser number of sexual polyps, occur amongst the Alcyonidæ, as well as amongst the Pennatulidæ, in which they are so well known from Kölliker's great work, appears to be new to science. That in such colonies and in *Heliopora* the "Dorsalfächer" are all turned towards the axis of the colony and directed upwards is also a new fact. The zooids in their structure seem to conform very closely to those of Pennatulids (*Sarcophyllum*, e. g.); but to the list of distinctive differences between the zooids and polyps of Pennatulids given by Kölliker, viz. the absence in the zooids of tentacles, the presence of two mesenterial filaments (the dorsal ones), the absence of generative organs, and the shortening of the hypogastric region to such an extent that it fuses with the anastomosing canal-system—to these marks of distinction must be added, in the case of the zooids of *Sarcophyton*, the fact that four of the mesenteries, the dorsal and ventral pairs, are deeper than the others.

It seems extremely difficult to reconcile the extraordinary succession of the mesenteries in the development of the Zoantharians, discovered by Lacaze-Duthiers, with the facts presented by Alcyonarians. Did the development of the eight mesenteries of Alcyonaria correspond with that of the first eight mesenteries formed in Actiniadæ, the first mesenteries formed would be either the lateral dorsal or lateral ventral; but these are those which are most rudimentary in the zooids of *Sarcophyton*. Moreover the mesenterial filaments of the two lateral pairs of septa are in the development of Actiniadæ the first to appear, and not the dorsal, which are longest in the Alcyonarian polyps and most persistent in the zooids. Apparently, however, development in Alcyonarians follows a different course.

In *Halysceptrum*, the development of which has been examined by Kölliker, the eight mesenteries appear from the very first. In *Kalliphobe* (Busch), one of the *Edwardsiæ*, according to Metschnikoff, the larva has, in its earliest stage, eight tentacles and two mesenterial filaments.

The peculiarities presented by the Stylasteridæ have struck many observers. M.-Edwards and Haime placed these corals (Stylasteracea) under the Oculinidæ. Gray, however, established a family (Stylasteridæ) for the genus *Stylaster* alone. Pourtales, who in his 'Deep-Sea Corals' dwells upon the many peculiarities of the corallum of this family, places under it the genera *Allopora*, *Stylaster*, *Distichopora*, *Cryptohelia*†, *Lepidopora*, and *Errina*. The

* An examination of the Cornulariadæ, the only recent solitary Alcyonarians, might very possibly throw light on the question of the affinities of the Rugosa.

† Pourtales has remarked that the genus *Endohelia* of M.-Edwards and Haime appears undistinguishable from the genus *Cryptohelia* of the same authors. *Endohelia* is founded on a Japanese species. The 'Challenger' dredged a coral certainly not generically distinguishable from *Cryptohelia* off the coast of Japan.

peculiarities in the structure of the soft parts, and the relations of the tentacles to the septa, described in this paper as occurring in a *Stylaster* and a *Cryptohelia*, and the similar facts observed by Sars in the genus *Allopora*, strengthen the facts brought forward by Pourtales, with regard to the coralla, in a very potenmanner. I hope to make a close study of the structure of *Stylaster*. The apparent absence of mesenteries is most remarkable, and a similar condition appears to occur also in *Millepora*. The number of tentacles and septa in the Stylasteridæ seems hardly to follow the usual hexameral law. In the species of *Stylaster* examined by me there are invariably twenty-two septa and twenty-two tentacles. In *Stylaster erubescens*, Pourtales describes the septa as being in number from nine to twelve, most frequently eleven. In *Allopora miniata* the septa are from seven to ten, generally eight. *Cryptohelia* has commonly sixteen.

With regard to the affinities of the Milleporidæ, no certain conclusion can be arrived at from the few facts yet ascertained. I hope to obtain specimens at Hawaii in sexually mature condition.

H.M.S. 'Challenger,' North Pacific.
21st July, 1875.

Postscript.

Since the above was written I have been able to refer at Honolulu to Prof. Lacaze-Duthiers's 'Histoire Naturelle du Corail.' I therefore add a few notes.

In *Corallium* the contracted polyp presents externally at the surface eight lobes coloured red. When the polyp is expanded, these lobes form a coloured cup with eight dentations at its margin, which surrounds the lower part of the expanded colourless polyp (see pl. 2 of Prof. Lacaze-Duthiers's work). The eight lobes described as closing the mouth of the calicle in the contracted polyp of *Heliopora* probably occupy a similar position, and have a similar appearance in the expanded condition of the polyp.

In *Corallium* the pinnæ or barbules of the tentacles are all severally introverted (*l.c.* p. 57), as well as the tentacles themselves. In *Heliopora* this appears not to be the case. In the hard tissue of *Corallium* boring vegetable parasites occur, as observed in *Millepora* and *Pocillopora*.

I have further been able to refer to Dana's great work on Corals in the splendid collection of scientific works in the Government Library at Honolulu, and to other works relating to *Heliopora*.

Dana states (U.S. Expl. Exped. vol. vii. Zoophytes, J. D. Dana, Philad. 1846, p. 539) that the blue colour of *Heliopora* is of animal origin and is lost on immersion of the coral in nitric acid. The colouring-matter was not analyzed by Mr. Gilliman.

In the Atlas of the 'Voyage de l'Astrolabe,' Zoophytes, pl. 20. figs. 12, 13, 14, the expanded polyps of *Heliopora cærulea* are figured by MM. Hombron and Jacquinot. In fig. 14 sixteen very short, simple, conical tentacles are shown, in fig. 13 only fifteen

tentacles. The figures are evidently very erroneous. The corresponding description I have been unable to refer to, the volume containing it being wanting in the Hawaiian Government copy.

In the Zoology of the 'Voyage de l'Uranie,' Quoy and Gaimard, Paris, 1824, p. 656, is a description of the polyps of *Heliopora* (*Pocillopora*) *cærulea*.

The expanded polyps have radiated tentacles, and are said to entirely hide the corallum when they are in an expanded condition. Experiments proved that communication between the animals is somewhat imperfect, since a stimulus applied to any part of the colony caused only the polyps in that immediate neighbourhood to retract themselves.

In the plates of the 'Voyage de l'Uranie,' pl. 96. figs. 5, 6, 7, *Heliopora* is figured, showing in fig. 5 the appearance of the coral in the fresh state, but without any representation of the polyps.

December 9, 1875.—Dr. J. Dalton Hooker, C.B., President, in the Chair.

"On the Development of *Lepas fascicularis* and the '*Archizoëa*' of Cirripedia." By R. von Willemöes-Suhm, Ph.D., Naturalist to the 'Challenger' Expedition.

The materials for this paper were obtained during the 'Challenger's' cruise from Japan to the Sandwich Islands in 35° lat. N., when very curious *Nauplii*, some of them 12 millims. long, were caught, which were identified at once as belonging to the nauplian form to which Dohrn has given the generic name of "*Archizoëa*." In the daytime these larvæ were scarcer, but at night so common that large bottles could be filled with them. The question (which had been left open by Dohrn) to which cirriped these extraordinary *Nauplii* might belong was solved when large quantities of *Lepas fascicularis* were seen passing the ship for more than a week. It was then possible to keep these barnacles alive and to bring up in our globes such stages of the large *Nauplii* as had also been taken on the surface. Then, again, when catching the surface-animals, free-swimming pupæ were found, which were seen to settle on dead *Velellæ* and assume the form of *Lepas fascicularis*, so that the whole development of this species could be worked out.

Reasons are given why this barnacle belongs to the species *Lepas fascicularis*; and a description is given of some parts of the mouth, which slightly differ from those described by Darwin in the same species.

I. *Development of the egg and of the youngest* Nauplius.

The conclusions to which an investigation into the development of the ovum, and into the changes which occur in it after its formation up to the time when the *Nauplius* comes out, has led are the following :—

1. The youngest eggs, seen in the cæca of the ovarian tubes, are transparent cells with nucleus and nucleolus.

2. The germinal vesicle, as well as the ovum, grows by taking up elements of yelk.

3. All the ova found in the ovary of a barnacle are in the same stage of development. When mature ova are to be seen in the tube, small undeveloped ova may be seen here and there in the cæca, which act very likely as mother cells for further breeding-purposes.

4. The spermatozoa, when fully developed, are simple hair-like filaments.

5. The mature ovum, as contained in the breeding-lamellæ, shows no trace of the vesicula germinalis or of its nucleolus. Some highly refractive granules may be seen here and there among the yelk-globules. The ovum is oval in form.

6. The segmentation is very irregular, but seems to be complete.

7. As soon as the segmentation begins, large transparent cells are seen separating themselves from the yelk-globules, and increasing in number as the segmentation goes on.

8. These cells form a blastoderm round the yelk. No primitive streak could be seen; but its presence is not denied, as the object is not favourable for these observations.

9. The blastoderm loses its cellular structure and gives way to a granular skin. On both sides of a longitudinal groove three pairs of appendages begin to be visible.

10. The test of the ovum extends as the embryo develops. The latter is very likely still enveloped by a thin blastodermic cuticle, which is clearly visible at the ends of the tail and antennæ when it comes out.

11. The development of the *Nauplius* in the ovum of this *Lepas* shows very much the same stages as those described by Buchholz in *Balanus improvisus*.

II. *The* Nauplius *stages.*

1. The *Nauplius* of *Lepas fascicularis* has, on leaving the egg, a length of 0·35 millim. It moults at least five times, and has before throwing off for the last time the Nauplial appendages a length of 12 millims.

2. The first stage of the *Nauplius* has been seen by Darwin, who describes it, and also by Burmeister.

3. After the first two moults the *Nauplius* gets a large dorsal spine and enters a series of stages, one of which has been described in another *Lepas* by Dohrn as *Archizoëa gigas*.

4. Reasons are given why *Archizoëa gigas* is nearly certain to be the *Nauplius* of *Lepas australis*, a species closely allied to *Lepas fascicularis*, and representing it south of the equator. *Archizoëa gigas* was caught, together with the large *Cyprides* of *Lepas australis*, during the 'Challenger's' antarctic cruise.

5. The tail and the caudal spine of the newly hatched *Nauplius*

are pushed in like the tubes of a telescope, and covered by a thin cuticle, which may be the blastodermic one. The same envelops also the lateral horns, but has not been seen at the end of the appendages. The carapax is as yet quite smooth, with the lateral horns hanging down.

6. After the first moult the tail and its spines, which have been pushed out, have a considerable length, and the lateral horns are erected. Only a single pair of small spines is to be seen on the carapax. The glands inside are unicellular.

7. The *Nauplius* after the second moult has, besides the dorsal spine, a series of processes all round the edges of the carapax, to which the unicellular glands send their ducts. Besides the œsophagus, two glands, which formerly were indicated by an agglomeration of cells, become visible. These glands are very likely those which, in the *Cypris* stage, terminate in the sucker of the antennæ, and are known under the name of cement-glands. Mouth and anus are present. One pair of movable spines on the tail. First "*Archizoëa* stage."

8. Length of *Nauplius* in the fourth stage 6 millims. Three or four movable spines on the tail, with the six of the next stage shining through the chitinous coverings. The glands of the carapax are in connexion with nerves, and present a large network. No nerve-terminations on the lateral horns or on the feelers. All the processes of the carapax, as well as the lateral horns, have openings at the top for letting out the secretions of the glands.

9. Length of *Nauplius* in the fifth and last stage 12 millims. Six movable spines on the tail.

Large masses of fat are assembling in the carapax, and the *Cypris*-shell is forming underneath it. The first pair of appendages develops inside the antennæ of the *Cypris*, the sucker being formed in the fourth joint, the second of the future antenna. Large compound eyes become visible on both sides of the central eye.

10. The carapax of the *Nauplius* has now a diameter of 2 millims. The appendages are very much like those of *Archizoëa gigas*, in which Dohrn, however, has taken the third pair of appendages for the second, and the second for the third.

11. A specimen of the supposed larva of *Lepas australis* (Dohrn's *Archizoëa gigas*) is figured in the stage just before the metamorphosis into the *Cypris*-stage takes place ; the two large compound eyes are already developed.

III. *The* Cypris *or pupa stage.*

1. The *Cypris* of the Atlantic (*C. fascicularis*) has been already described by Claus, who has established the homology of its parts with the Copepods.

2. Darwin has described the very large *Cypris* of *Lepas australis* (length 3 millims.), which is in every way similar to that of the present species—a further proof of the probability of the suggestion that Dohrn's large *Nauplii* are the larvæ of that species.

3. Our *Cypris* has a length of 1·3 millim.

4. A description is given of the antennæ with the suckers and their glands, the development of which from the glands in the labrum has been mentioned already. The parts of the mouth (small labrum and three pairs of maxillæ and maxillipeds) and the natatory feet, as well as the caudal appendages with the anus at their base, are figured and described. The organs of sense, the digestive organs, and the shell-gland, which is now very conspicuous, offer scarcely any thing that has not been seen already by Darwin and Claus in the *Cyprides* of the different species of *Lepas*.

IV. *The metamorphosis of the* Cypris *into the young* Lepas.

1. The pupæ are chiefly caught at the very surface of the sea, where they swarm round the dead *Velellæ*, on which they settle. They rarely take to a colony of old barnacles.

2. Soon after settling the new cirri are formed underneath the natatory feet, the head grows out, the eyes are absorbed, and under the *Cypris*-shell the primordial valves of the young *Lepas* appear, which persist during its whole life. The *Cypris*-shell, with the old natatory feet, is then thrown off.

3. The young *Lepas* begins to form the complete shell, and fastens itself more and more by the copious secretions of its glands, which run through the outdrawn and enlarged head into the fixing-antennæ.

4. The cirri of the young *Lepas* develop a larger number of joints, the shell begins to lose its transparency, the body inside turns over a little, as has been described by Darwin, and the young *Lepas* is complete.

Conclusion.

1. As the young stages of the Lepadidæ are pelagic, it is only possible to work out their development at sea, and there at certain seasons. We found only once before the large *Nauplii* of *Lepas australis*. The development of no one of the Lepadidæ has hitherto been known in full; and it seems that even the adult larvæ of our commonest barnacles, such as *L. anatifera* and *L. anserifera*, are as yet unknown.

2. The *Nauplius* stages of *Lepas fascicularis* have not a different morphological value from those of *Balanus* and other genera; therefore there is no reason for giving to this stage a particular name. The term "*Archizoëa*" may remain as a remembrance of Dohrn's interesting discovery, but cannot be applied to the larvæ of other Lepadidæ.

H.M.S. 'Challenger,' Honolulu,
July 28, 1875.

"Preliminary Remarks on the Development of some Pelagic Decapods." By R. von Willemöes-Suhm, Ph.D., Naturalist to the 'Challenger' Expedition.

Since we left Australia I have investigated the metamorphoses of some Crustacea which have been constantly caught by us on the surface of the tropical and subtropical parts of the Pacific. Though these investigations will be continued, I have now arrived at certain results which I think will not be uninteresting to zoologists. The genera to which these remarks refer are *Amphion*, *Sergestes*, and *Leucifer*.

Amphion Reynaudi has been on our lists as an animal "*incertæ sedis*" (Milne-Edwards) for nearly forty years, until Dohrn proved that a full-grown specimen of it, which he dissected, was in possession of branchiæ and of an ovary, therefore no doubt a mature form. He also described one of its young stages, which has the number of appendages of a *Zoëa*, but in which caudal appendages are already developed.

On our voyages in the 'Challenger' we have caught several specimens of *Amphion* and of its larvæ; and I am now able to produce drawings, not only of the *true Zoëa* with a simple telson, but also of all the intermediate stages between it and the adult form with two, three, four, five, and six pairs of walking-legs. Of the full-grown *Amphion* I have examined three specimens, two of which are undoubtedly males, as the testes (and the branchiæ) were plainly visible, the former opening into the last pair of legs.

There is now no doubt that *Amphion* is not a larva, nay, even that there are several species and perhaps genera of this remarkable form. We have caught two very interesting mature animals which are certainly closely allied to *Amphion*. One of these has enormously long eye-stalks, which, having a length of 7 millims., are just as long as the whole animal's body. Another form has got very long eye-stalks too, but is especially remarkable for the antepenultimate joints of its pereiopods, being large paddle-shaped organs, terminated by a very small end-joint. Both have got, like *Amphion*, a central (Nauplial) eye and eight pairs of branched legs; but their body is more *Sergestes*-like and less flat than that of *Amphion*. They certainly both belong to the same genus, and may be called *Amphiones* until more than one specimen of each has been obtained.

To me these Amphionidæ are especially interesting, as I can compare them with the larvæ of *Sergestes* and *Leucifer*, the former of which have also got eight pairs of branched legs and the central eye which persists in the Amphionidæ. There are good reasons for the statement that the larvæ of *Leucifer* and *Sergestes* pass through an *Amphion*-stage; and this, it seems to me, throws a good deal of light on the relations and systematic position of *Amphion* itself.

Dohrn, to whom we owe so many fine discoveries concerning

the pelagic Crustacea, has described *, under the name of *Elaphocaris*, a small and very spiny *Zoëa* caught in the harbour of Messina. He calls it the larva of a Decapod without fixing its position. This small larva was often seen by me in the Atlantic; but I only lately found out that *Elaphocaris* is the larva of a species, or rather of some species, of *Sergestes*. There is, however, one species of this genus in which the *Zoëa* is not an *Elaphocaris*, but a larger, less spiny form, similar, however, in all other respects to the former. Of the species which develops with an *Elaphocaris*-stage in the Western Pacific, I have collected numerous specimens of all the stages, from the youngest Zoëas up to the mature animal. The mode of development is very simple. After the first moulting the larva gets six more branched legs and loses many spines. It enters the *Amphion*-stage, then moults, throws the branched legs off, gets branchiæ, and becomes a young *Sergestes*. Only after this last moulting the central eye, hitherto present, disappears.

And very similar to that of *Sergestes* is the development of *Leucifer*. Here the earliest *Zoëa* of a species from the Western Pacific has got at first no eyes, then sessile ones come out, and the animal then presents the form which Dana has called *Erichthina demissa*, and which Claus suspected to be not a Stomatopod but a Schizopod larva. After the second moulting this *Erichthina* gets stalked eyes and very long setæ on all its appendages, becoming a rather long, very delicate *Zoëa*. It now enters the *Amphion*-stage, but never gets more than four pairs of pereiopods, and loses another pair of these when it moults for the youngest *Leucifer*-stage, in which two pairs of pereiopods are absent.

The next question, after having found this out, was, of course, whether *Amphion*, *Sergestes*, and *Leucifer* leave the egg as a *Zoëa*, or whether there is a preceding *Nauplius*-stage. My own impression is that in the two first-named genera this is not the case, as the youngest Zoëas which I caught had all the same size, and as none of them was without the large lateral stalked eyes. As for *Leucifer*, the question appears to me to be doubtful; for it is, from what I have seen, quite possible that my youngest *Zoëa*, which has only got a central eye, may be preceded by a *Nauplius*. Of course the simplest thing would be to get the eggs; but there is the difficulty, for *Amphion* is caught very rarely, and has never been obtained at any other time but between 8 and 12 P.M., when it is extremely difficult by lamplight to find out the youngest stages. *Sergestes* larvæ are commoner, appearing also in the daytime, and *Leucifer* is sometimes caught in abundance. I hope, therefore, that I shall succeed in completing my researches about this question, especially as far as the latter two genera are concerned.

H.M.S. 'Challenger,' Honolulu, Sandwich Islands,
July 30, 1875.

* V. Siebold und Kölliker, Zeitschrift für wissenschaftliche Zoologie, Band xx. p. 662, tab. 31. fig. 28.